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HS29-1TH3P-0281 REGIONAL PREDICTIONS IN UNGAUGED BASINS THROUGH PHYSIOGRAPHICAL SPACE-BASED INTERPOLATION

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1. ORIGIN OF THE STUDY

The scientific literature recently proposed a physiographical space-based kriging methodology for regional flood frequency estimation (Chokmani and Ouarda, 2004). This methodology applies a geostatistical technique to interpolate flood quantiles on a continuous physiographical space, whose coordinates are an appropriate set of catchment descriptors. The proposed methodology is suitable for ungauged sites and capable of capturing the spatial correlation structure of the variables in the physiographical space.

2. AIMS OF THE STUDY

The present analysis further investigates the applicability of spatial interpolation techniques for streamflow prediction in ungauged basins. In particular, the analysis:

A) focuses on the estimation of the probability weighted moments (PWMs) of annual maximum series of floods of order 0 (i.e., mean), 1 and 2 (PWM_0, PWM_1 & PWM_2)

[*Sample estimators of PWM tend to be less biased than estimators of traditional statistical moments for small samples and can be effectively utilised for estimating the parameters of several freq. distributions (e.g.* Hosking and Wallis, 1997)];

B) concerning the estimation of PWMs of annual flood series, compares a number of spatial interpolation techniques, deterministic and statistic, applying them in the physiographical space

[*DETERMINISTIC: IDW - Inverse distance; DTR - Delaunay triangulation (Voronoy diagrams, Thiessen polygons); GRA – Griddata; GRD – Gridfit (GRA and GRD are surface-fitting procedures implemented in Matlab); STATISTIC: OKR – Ordinary Kriging; DKR – Ordinary Kriging on Detrended Residuals -* Isaaks and Srivistava (1989) *and* Watson (1992)].

3. STUDY AREA (Fig. A)

The study area consists of 58 unregulated Apenninic catchments located in northern-central Italy, for which several geomorphologic and climatic descriptors are available.

All heterogeneity measures proposed by Hosking and Wallis (1997) indicate that the regional flood frequency regime should be regarded as "definitely heterogeneous".

The Generalized Extreme Value (GEV) distribution is a suitable parent distribution for all observed AMS of flood data (see e.g., Castellarin et al., 2001 & 2007).

Seven different pairs of catchment descriptors were used in the study as coordinates X and Y for the application of the spatial interpolators. The results reported here refer only to two pairs: MAP-A_{imp} (**Option 1**) and MAP-τ_c (**Option 5**), where MAP [mm] is the mean annual precipitation, A_{imp} [km^2] the impervious area of the catchment, τ_c [hr] the catchment concentration time.

Concerning the estimation of PWM_0 and Option 1, Fig. B presents some examples of interpolated surfaces [*MAP, Aimp and PWM_0 values were log-transformed and standardised*].

Fig. A – Study area

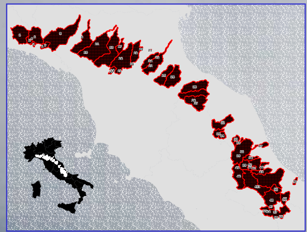
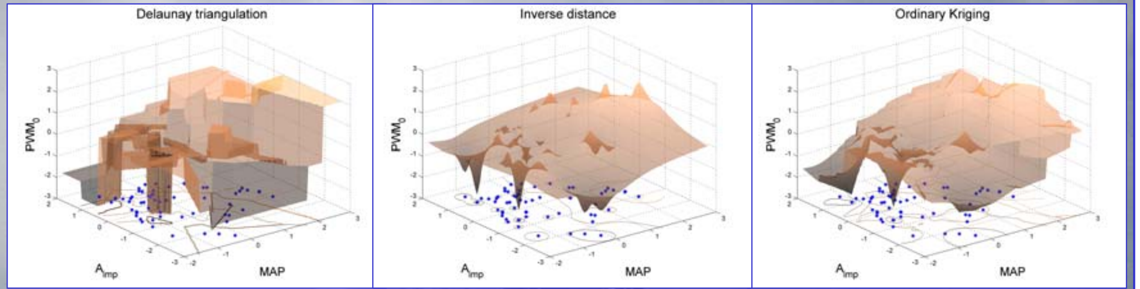


Fig. B – Example of physiographical space-based interpolation using three interpolators. Dependent variable: PWM_0 (mean annual flood); independent variables: A_{imp} (impervious area) & MAP (mean annual precipitation) –*variables were log-transformed and standardised*-



4. CROSS-VALIDATION PROCEDURE

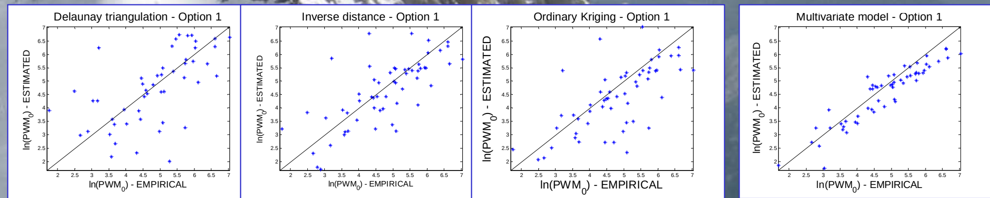
The reliability of each technique is first assessed through a comprehensive "leave-one-out" cross-validation procedure (see e.g., Castellarin et al., 2001 & 2007) that focuses on the estimation of sample PWMs of order 0, 1 and 2.

Concerning the estimation of PWM_0 and Option 1, Fig. C shows the scatter plots for three different spatial interpolators and enables the comparison with the scatter plot resulting from the cross-validation of a multivariate model (log-linear regression) identified under the same hypotheses.

Secondly, the relative errors of the 10- and 50-year flood quantiles were analysed. The errors were computed by comparing the at-site estimates of the flood quantiles with corresponding estimates obtained by using the cross-validated PWM. Only sites with at least 10 and 25 years of observation were considered for the estimation of 20- and 50-year floods. All flood quantiles were estimated using the GEV-PWM algorithm (*GEV parent, parameters estimated though the PWM method*).

Concerning Options 1 and 5, Fig. D reports the relative errors obtained for all spatial interpolators. Concerning Option 1, Fig. D compares the relative errors associated with the two best performing spatial interpolators and a multivariate model (*log-linear regression*).

Fig. C – Cross validation procedure: scatterplots for three different interpolators and a multivariate model. Dependent variable: PWM_0 (average of annual maximum floods); independent variables of Option 1: A_{imp} (impervious area) & MAP (mean annual precipitation)

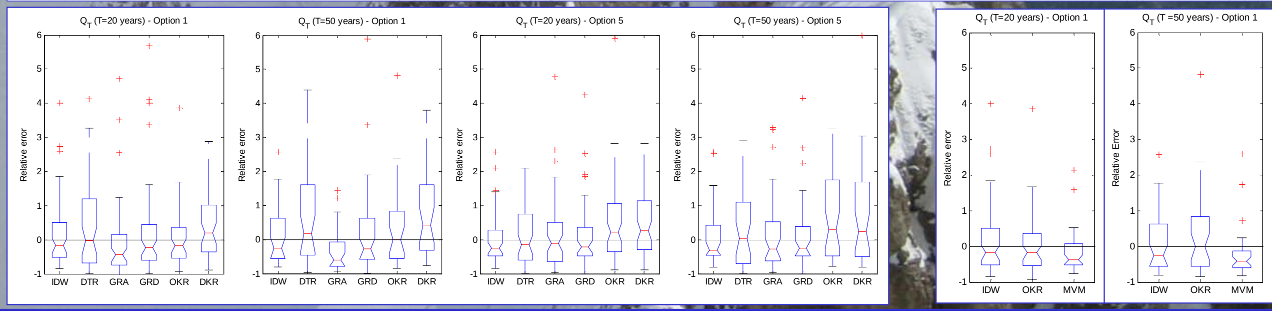


5. RESULTS AND DISCUSSION

(*for the study area considered herein*)

- For a given a set (pair) of catchment descriptors, different spatial interpolators are associated with different degrees of reliability in the estimation of flood quantiles at ungauged sites. The reliability may vary significantly regardless of the nature of the interpolator (i.e., deterministic or statistical).
- Interpolators that represent the dependent variable (i.e., PWMs) through step-functions (i.e., Delaunay triangulation, Thiessen polygons) are associated with the poorest performance indices.
- Complex geostatistical interpolators and easy-to-use deterministic procedure (e.g., IDW - inverse distance) seem to be characterised by similar performance indices.
- For a definitely heterogeneous region and a given a set (pair) of catchment descriptors, spatial interpolators may outperform multivariate models (i.e., log-linear regression models) for the estimation of flood quantiles in ungauged basins.

Fig. D – Cross validation procedure: relative errors of flood quantiles (recurrence interval T = 20, 50 years) for several interpolators applied with Options 1 and 5 (IDW - Inverse distance; DTR - Delaunay triangulation; GRA – Griddata; GRD – Gridfit; OKR – Ordinary Kriging; DKR – Ordinary Kriging on detrended residuals); for Option 1: comparison of the two best performing ones (IDW and OKR) with a Multivariate model (MVM) –*some outliers may exceed 6*-



REFERENCES

Castellarin, A., D.H. Burn, A. Brath (2001) Assessing the effectiveness of hydrological similarity measures for regional flood frequency analysis, J. Hydrol., 241(3-4), 270-285.

Castellarin, A., R.M. Vogel, N.C. Matalas (2007) Multivariate probabilistic regional envelopes of extreme floods, J. Hydrol. 336/3-4, 376-390, 10.1016/j.jhydrol.2007.01.007.

Chokmani, K., Ouarda, T. (2004) Physiographical space-based kriging for regional flood frequency estimation at ungauged sites. Water Resour. Res. 40(12): doi: 10.1029/2003WR002983.

Hosking, J.R.M., J.R. Wallis (1997) Regional frequency analysis – An approach based on L-moments, Cambridge University Press, New York.

Isaaks, E. H., R.M. Srivistava (1989) *Applied Geostatistics*, Oxford Univ. Press, New York.

Watson, D.E. (1992) *Contouring: A Guide to the Analysis and Display of Spatial Data*, Pergamon, Elsevier Science.